D Australia's electricity generation sector

The Commission's stocktake of emissions-reduction policies identified around 240 policies in Australia, at the Commonwealth and state levels. This appendix focuses on major emissions-reduction policies that directly relate to the electricity generation sector. Some transport polices (such as major biofuel policies and fuel taxes) are discussed and quantified in Chapter 5, while energy efficiency policies (including information programs) are examined in Appendix C. Research and development policies, land management and forestry policies and government procurement policies are not analysed in detail.

The Commission estimated the impacts of the following Australian electricity sector policies:

- the Renewable Energy Target (RET)
- solar feed-in tariffs (FITs)
- the NSW and ACT Greenhouse Gas Reduction Scheme (GGAS), and
- the Queensland Gas Scheme.

A number of other Australian electricity-sector emissions-reduction policies were considered, but not included in the analysis. In general, where policies were not included in the analysis, it was because the Commission considered that they were unlikely to make a material difference to the aggregate estimates (section D.9)

The policies have been evaluated for the 2009 or 2010 calendar year (depending on data availability). All estimates are expressed in 2010 dollars.

D.1 Electricity generation in Australia

Australia's electricity generation sector can be broken down into three systems:

- the National Electricity Market (NEM), which operates in the eastern states
- the Wholesale Electricity Market, which operates in Western Australia

- the Northern Territory, which is serviced by an integrated electricity utility.

The electricity transmission network for the NEM has interconnectors through Queensland, New South Wales, South Australia, Victoria and the Australian Capital Territory. There is also an undersea interconnector between Victoria and Tasmania. The electricity transmission networks in Queensland, New South Wales, the Australian Capital Territory and Tasmania are owned by state governments. In contrast, the transmission networks in Victoria and South Australia are privatised, while the interconnectors are also privately owned. The transmission network service providers are regulated by the Australian Energy Regulator.

The NEM operates as a mandatory wholesale pool under the management of the Australian Energy Market Operator. Generators sell their electricity into the pool and retailers (and some large users) buy electricity from the pool to on-sell to residential and business consumers. Around two-thirds of electricity generation capacity in the NEM is government-owned. Generators make bids to supply electricity into the pool at five-minute intervals, and bids are accepted in price order (lowest-price bids are accepted first, up to the point where supply is equal to demand). The 'dispatch price' for each five-minute interval is set equal to the price of the last bid needed to meet the demand at a given period, and the wholesale spot price is calculated every 30 minutes as the average of the 'dispatch prices' for the six five-minute intervals that make up the period. The maximum spot price is capped at A$12 500/MWh, while the minimum spot price is minus A$1000/MWh. Generators might offer negative bids if it is not possible (or costly) for them to switch off their supply. This can be the case for wind farms, and for some thermal plants (AEMO 2010a, Energy Supply Association of Australia 2010).

While most physical electricity is traded through the central pool, generators and retailers also enter into financial contracts to hedge against the volatility in the spot market. For example, a retailer may contract with a generator to effectively purchase electricity for A$40/MWh (the 'strike price') in a given period. If the NEM spot price in that period turns out to be above the strike price, the generator pays the difference to the retailer. If the NEM spot price is below the strike price, the retailer pays the difference to the generator. These trades are settled through cash payments rather than the physical delivery of electricity at the agreed price.

There is retail competition in most NEM regions with private retailers being the major players in Victoria, South Australia and Queensland. Some retailers are vertically integrated and also own generation capacity. The single retailer in Tasmania is owned by the Tasmanian Government. The regulation of retail electricity prices is a state government responsibility, and states have implemented a mix of regulations.

In Western Australia, the main electricity transmission networks — South West Interconnected System, North West Interconnected System and Esperance System — are owned by Western Power and Horizon Power, both state government trading enterprises. The networks are not connected to other states or the Northern Territory. In addition to conventional electricity generation, there is also isolated cogeneration in the Pilbara and other regions.

In the South West Interconnected System, most electricity is traded through bilateral contracts between generators and retailers. There is also a short-term energy market to provide electricity to balance supply and demand at short intervals. This market is operated by the Independent Market Operator. One difference between the South West Interconnected System and the NEM is that in Western Australia generators receive additional payments to provide capacity, irrespective of the amount of electricity they supply.

The Northern Territory system is operated by an integrated government utility that is responsible for generation, transmission and retail. As such, there is no competition in these sectors.

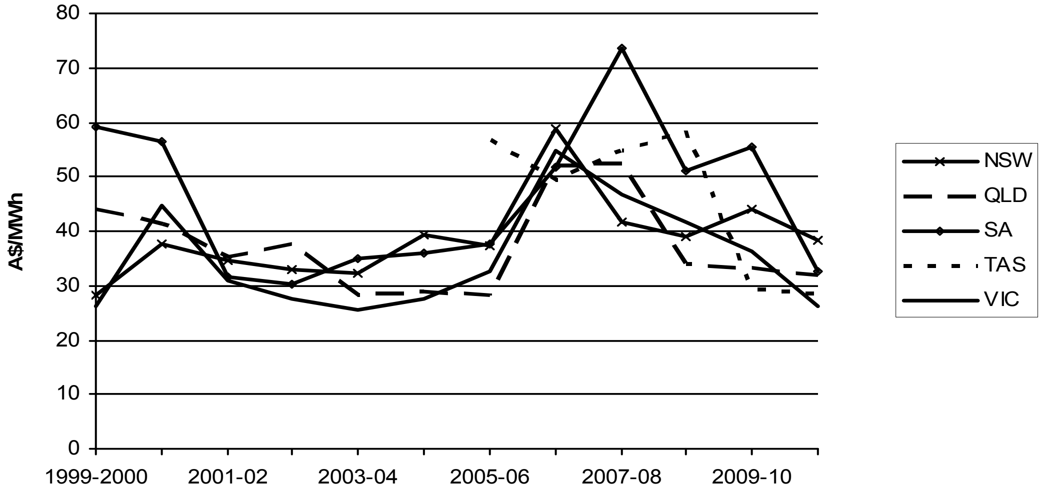
Key statistics

Wholesale electricity price

Wholesale electricity prices in the NEM regions vary, but over the period 1999–2011 exhibited similar trends (figure D.1). Average peak and off-peak prices in the regions have varied significantly over the first four months of 2011 (table D.1) (it should be noted that these data are likely to reflect seasonal factors, because they only cover the first four months of the year). Data on wholesale prices in Western Australia were not available (because most electricity is traded through bilateral contracts). However, in 2010, the average clearing price on the Western Australian short-term electricity market was around A$29/MWh. Data on prices in the Northern Territory were not available.

Figure D.1 **Average NEM wholesale electricity prices**

Australia, 1999–2011, Nominal prices



Source: AEMO (2011a).

Table D.1 **Average NEM prices**

Australia, January 2011 to April 2011

Region	*Daily average*	*Peak average (7am–10pm)*
	A$/MWh	A$/MWh
New South Wales	59	98
Victoria	33	45
Queensland	50	81
South Australia	46	76
Tasmania	27	29

Source: AEMO (2011b).

Fuels used in electricity generation

The majority of the electricity generated in Australia is derived from coal and gas. Hydroelectricity is the largest renewable energy source (table D.2).

Table D.2 **Electricity generation fuel use**

Australia, July 2008 – June 2009

Fuel source	*Total generation*	*Proportion of total*
	TWh	%
Black coal	143	55
Brown coal	57	22
Oil	3	1
Gas	39	15
Renewables		
Hydroelectricity	11.9	5
Wind	3.1	2
Solar	0.3	–
Biomass	1.5	1
Biogas	1.3	–

– nil or rounded to zero.

Source: ABARES (2011).

Emissions

In 2010, total emissions from the Australian electricity sector were 196 Mt CO_2-e (DCCEE 2011a). The emissions intensity of the fuels used to generate electricity in Australia varies significantly. The Commission has estimated the average emissions intensity of fossil-fuel generation in Australia using a weighted average based on 2010 plant-level emissions and generation estimates from Frontier Economics (unpublished data), and Australian electricity generation data from the Australian Bureau of Agricultural and Research Economics and Sciences for 2008-09 (table D.3).

Table D.3 **Average emissions intensity of electricity generation**

Australia, 2010

Fuel	*Emissions intensity (t CO_2/MWh)*
Brown coal	1.20
Oil	0.97
Black coal	0.92
Gas	0.54
Renewables	0.00
Australian coal average	**1.00**
Australian fossil fuel average	**0.92**

Sources: ABARES (2011); Frontier Economics (unpublished data); Productivity Commission estimates.

D.2 Abatement

In order to estimate the abatement attributable to various policies, the Commission has generally assumed that lower-emissions generation induced by the emissions-reduction policies displace a mix of fossil-fuel generation having an emissions intensity equal to the average emissions intensity of fossil-fuel generation in Australia (0.92 t CO_2/MWh). Using the Australian average may overstate the amount of abatement in Western Australia where there is a relatively large share of gas generation, compared with the NEM. For sensitivity analysis, the Commission used the emissions intensity of gas-fired generation in Australia (0.54 t CO_2/MWh) and the weighted average emissions intensity of coal-fired generation in Australia (1 t CO_2/MWh).

D.3 Policy overlaps

As noted, the Commission has estimated the subsidy equivalent associated with four policy groups. It is important to identify any overlaps, to ensure that abatement is not overestimated by attributing the same abatement to multiple policies. The Commission considers that:

- the Queensland Gas Scheme does not overlap with the other policies, because generators cannot receive credit under this scheme if they have received another subsidy
- retailers in New South Wales and the ACT can use renewable energy certificates (RECs) to meet obligations under both the GGAS and the RET. The subsidy provided by RECs is covered under the estimation of the RET, and is not considered in the GGAS section
- renewable generators do not create New South Wales greenhouse gas abatement certificates (NGACs) under GGAS. Therefore, there was no overlap between GGAS and the RET and FITs (other than those discussed above)
- generators receiving FITs in 2010 were eligible to receive RECs. Thus renewable generation covered under the FITs is already included in the analysis of the RET.

Taking these relationships into account, the Commission has estimated the total abatement attributable to the policies as:

- gas generation induced by the Queensland Gas Scheme
- abatement induced by NGACs created under GGAS
- renewable generation induced by the RET.

The FITs are unlikely to have led to any additional abatement in 2010, and thus only the subsidy equivalent (and not abatement or the implicit abatement subsidy) was estimated.

D.4 Renewable Energy Target (RET)

The Mandatory Renewable Energy Target was introduced in 2001, with the intention of encouraging additional renewable electricity generation. Under this policy, generators that supplied renewable electricity generally received one (or more) RECs for each MWh of renewable electricity supplied above baseline production over the period 1994–1997. These RECs were sold to electricity retailers, who were obliged to surrender a given number of RECs each year.

In 2009, the Mandatory Renewable Energy Target was replaced by the RET. The new system offered five RECs for each MWh of renewable electricity supplied by small-scale solar systems. In addition, RECs for small-scale solar systems were 'deemed' — RECs were allocated up front for the projected generation from solar systems over the next 15 years. In response to the solar multiplier and deeming, the number of RECs issued to small generation units went from around 350 000 in 2008 to 21 million in 2010. Small generation units accounted for almost two thirds of RECs issued in 2010 (ORER 2011c).

The influx of small-scale RECs into the market led to concerns that the REC price would be depressed, and there would be little incentive for generators to enter into long-term contracts to build new large-scale renewable plants. To address these concerns, the RET was divided into two programs in 2011 — the Large-Scale Renewable Energy Target and the Small-Scale Renewable Energy Scheme. Retailers must purchase a specified number of certificates from each of these schemes. The solar 'multiplier' is scheduled to decline over time, which will reduce the costs of the scheme.

It is important to note that the year being analysed in this section, 2010, was unusual both in terms of the number of RECs created and the composition, being sourced mainly through small generation units and solar water heaters.

While large-scale renewables and small-scale renewables were part of the same scheme in 2010, the analysis of these components was conducted separately here. This was due to the differences in the allocation of certificates to these two components — while large-scale renewables were granted certificates each year on the basis of actual generation, small-scale renewables were granted certificates up front, on the basis of expected generation over their economic life (effectively a capital subsidy).

In addition, while solar hot water heaters are eligible to receive RECs under this scheme, they are not directly relevant to the electricity generation sector, and thus have been excluded from the analysis.

Large-scale Renewable Energy Target

Subsidy equivalent

The subsidy equivalent for the large-scale RET was estimated in a similar fashion to other renewable energy certificate schemes — the subsidy equivalent is given by multiplying the REC price by the number of certificates issued to *additional* generation.

The Commission has assumed that in this case all generation that receives certificates was 'additional'. Certificates under the RET are only issued for generation above a 1994–1997 average baseline. Therefore it has been implicitly assumed that all generation installed after this date was policy-induced. This is likely to lead to an 'upper bound' estimate of the subsidy equivalent and abatement, though evidence on the relatively high costs of building solar and wind plants would seem to support the conclusion that almost all solar and wind generation was policy-induced.

RECs are traded in two ways. The first is through long-term contracts between electricity retailers with REC obligations, and renewable energy generators. Typically these contracts have been 'power purchase agreements', where retailers agree to purchase electricity and the associated RECs from generators. These arrangements provide generators with a stream of revenue that they can use to obtain finance to build new plants (such as wind farms). The second way RECs are traded is through a 'spot' market, where RECs are traded separate from electricity. The Commission understands that the long-term contract price of RECs has historically been above the 2010 average spot price.

Historically, most RECs (around 90 per cent) created by large-scale projects have been traded through long-term contracts (AGL, pers. comm., 10 May 2011). This suggests that the relevant measure of the resource costs of large scale renewable energy projects is related to the contract REC price, not the spot price. Contract price data are not publicly available, so the Commission has estimated the contract REC price based on the cost of generating electricity using wind farms, and the average wholesale electricity price. The Commission's estimate of the contract REC price for this analysis is A$60 per REC (box D.1). Estimates of the subsidy equivalent use this figure as an upper bound, and the average 2010 spot market REC price (A$37.03) as a lower bound.

There were around 28.6 million RECs issued in 2010 (excluding solar water heaters), of which 7.6 million were granted to large-scale generation. Therefore, the subsidy equivalent for the large scale component of the RET was estimated to be between A$283 million and $459 million.

Box D.1 **The Commission's estimate of the contract REC price**

Because data on long-term contract prices for RECs are not publicly available, the Commission has estimated the contract REC price that would need to have applied in 2010 to meet the additional costs of wind power (the most widely used large-scale renewable). The contract REC price was estimated as the long-run marginal cost (LRMC) of wind power minus the average wholesale electricity price.

The Commission has assumed that the LRMC of wind power is A$110/MWh. This is based on data from Frontier Economics (unpublished data) that suggested that the LRMC of wind power projects in Australia was mostly in the range A$100–A$120/MWh.

The average wholesale price of electricity was assumed to be A$50/MWh (section D.1). This implies that for wind power projects to meet their LRMC, the REC price would need to be around A$60.

This estimate was based on a number of assumptions, and could be an under or over estimate of the average contract price of RECs. As this estimation reflects the current levelised cost of wind, it may be more likely to be an overestimate, as contracts signed in previous years may reflect the cost of wind farms built in better sites.

Abatement

Since one REC was equivalent to one MWh of renewable generation (above the baseline) for the large generation component, the increase in renewable generation attributable to that component was estimated to be 7.6 TWh. For the 'central' estimate of RET-induced abatement, each MWh of renewable generation was assumed to displace one MWh of fossil fuel generation with an average emissions intensity of 0.92 t CO_2/MWh. Hence, the estimated abatement for the large-generation component was 7 Mt of CO_2.

Small-scale Renewable Energy Target

Subsidy equivalent

In the case of small-scale projects, the REC price used to estimate the subsidy equivalent was the spot market price, because most RECs generated by small-scale projects were traded through the spot market. In 2010, small-scale generators received 21 million RECs, and the average spot price of RECs was A$37.03. Therefore, the total outlay received by small-scale generators was A$777 million.

As noted above, small-scale generators received RECs up front, on the basis of expected generation over their economic lifetime. Therefore, the subsidy was essentially for abatement that will take place over a number of years, and as such the subsidy was converted into an annualised value. The economic life of the investment was assumed to be 20 years, and the real discount rate used was 7 per cent. Therefore, the estimated subsidy equivalent was A$73 million.

Abatement

The estimated abatement for the small-scale component of the RET was total generation in 2010 receiving the RECs, multiplied by a counterfactual emissions intensity.

In 2010, approximately 19.8 million RECs qualified for the solar multiplier of five. Hence, these RECs were only associated with 4 TWh of estimated renewable generation (=19.8 million/5). The 1.2 TWh that was associated with the small-scale component, but was ineligible for the solar multiplier can be added without further adjustment. Thus, the estimated future renewable electricity generation as a result of capacity augmentation under the small-generation component in 2010 was around 5.2 TWh.

However, since these certificates were granted up-front for generation, which was assumed to occur over a 15 year period, another adjustment was necessary to estimate the annual generation.[1] Thus, the estimated annual renewable generation induced under the small generation component was estimated to be 344 GWh (5.2 TWh divided by 15 years).

1 The 15 year period is a policy parameter that reflects the policy assumptions about the number of years for which solar PV systems would be receiving RECs. This is different to the economic life of the investment, which is assumed to be 20 years, consistent with the assumption the Commission has used for other countries.

Using a counterfactual emissions intensity of 0.92 t CO_2/MWh, the abatement estimated to be attributable to the small-scale renewables in the RET was 317 kt CO_2.

Sensitivity analysis and implicit abatement subsidy

The implicit abatement subsidy for the RET depends on the assumptions used. The Commission has estimated the subsidy equivalent for the large-scale RET using REC prices of A$37.03 and A$60, and for the small-scale component using discount rates of 3, 7 and 11 per cent (real). Abatement was estimated using a range of counterfactual emissions intensities. The implicit abatement subsidy for the RET as a whole was estimated to be between A$42 and A$129/t CO_2 (with the large-scale component estimated at A$37–A$111/t CO_2 and the small-scale component estimated at A$152–A$525/t CO_2 (table D.4)

Table D.4 **Implicit abatement subsidy, Renewable Energy Target**
Australia, 2010

Component	*Subsidy equivalent*	*Abatement* *Low*	*'Central'*	*High*	*Implicit abatement subsidy*
	A$m (2010)		Mt CO_2		A$/t CO_2
Large scale					
Lower bound (REC price = A$37.03)	283	4	7	8	37–69
Upper bound (REC price = A$60)	459	4	7	8	60–111
Small Scale					
7% discount rate	73	0.2	0.3	0.3	230–425
3% discount rate	52	0.2	0.3	0.3	152–281
11% discount rate	98	0.2	0.3	0.3	283–525
RET Total	**335–556**	**4**	**7**	**8**	**42–129**

Source: Productivity Commission estimates.

D.5 State and territory solar feed-in tariffs

All Australian states have solar feed-in tariffs (FITs) of some description. The first solar FITs were implemented by Queensland and South Australia in 2008, with other states following in 2009 and 2010 (table D.5). The Commission has analysed the impacts of FITs in all states and territories except Tasmania and the

Northern Territory. In both these cases, the Commission was unable to access the relevant data. However, the size of these jurisdictions means that their exclusion from the analysis is not likely to make a significant difference to the totals.

FITs are paid either on a net or gross basis. Queensland, Victoria, South Australia and Western Australia have net FITs, where people who have eligible solar generation systems receive a payment for the electricity they export to the grid. For example, suppose a Queensland household generates 10 kWh of solar electricity in a day, but only consumes 5 kWh. If the household exports the difference to the grid, it would receive a payment of A$2.20 (5 kWh multiplied by 44 cents per kWh).

New South Wales and the Australian Capital Territory have gross FITs, where people who have eligible solar generation systems receive a payment for all electricity they generate, irrespective of whether it is exported to the grid or used by the household. So if an ACT household generates 10 kWh of solar electricity in a day, and consumes 5 kWh in the home, the household would receive a payment for the full 10 kWh — A$4.57 (10 kWh multiplied by 45.7 cents per kWh).

The difference between gross and net FITs means that care has to be taken in comparing FIT rates between states, and has implications for calculating the subsidy equivalents.

Table D.5 **Solar feed-in tariffs by region**
Australia, 2010

Region	*Commenced*	*Rate*	*Type*
		c/KWh	
New South Wales	January 2010	60 for systems installed before 27 October 2010 and 20 for systems installed after[a]	gross
Australian Capital Territory	March 2009	45.7	gross
Victoria	November 2009	60	net
Queensland	July 2008	44	net
South Australia	July 2008	44	net
Western Australia	August 2010	40	net

[a] The analysis does not include changes to the NSW FIT scheme that were announced in May 2011. These changes would reduce the FIT payable to households that installed solar photovoltaic systems from 60 cents/kWh to 20 cents/kWh.

Source: APH (2011).

Subsidy equivalent

The Commission obtained data on the capacity of eligible solar generation that was installed at the end of 2010. However, the Commission was not able to obtain data on generation from solar photovoltaic (PV) systems, or on when the systems were installed during 2010. Instead, for Victoria, Queensland and South Australia, the Commission has made the assumption that all capacity that was installed at the end of 2010 had been installed for the entire year. This is likely to overstate the generation from solar PV in these states in 2010, and as a result overstate the subsidy equivalent. The estimates should accordingly be treated as upper bounds.

In the case of New South Wales, the FIT rate changed during 2010. To account for this, the Commission has assumed that capacity was installed evenly throughout 2010. The Western Australia FIT only commenced operation in August 2010. To account for this, capacity was assumed to be installed evenly from the start of the program in August 2010 to the end of 2010.

Estimating subsidy equivalents for net FITs

The subsidy equivalent is equal to the production subsidy equivalent (φ) multiplied by the quantity of electricity that receives the FIT. In the states with a net FIT (Victoria, Queensland, Western Australia and South Australia) the production subsidy equivalent was estimated as the difference between the FIT and the daytime wholesale electricity price (daytime prices are used because solar PV systems generate electricity only during daylight hours). This captures the unit mark up over the price that households would receive for selling electricity to the grid without assistance:[2]

$$\varphi_{i,x} = FIT_i - p_i$$

The quantity of electricity eligible for FITs (q_i) was estimated using the installed capacity (c_i), the capacity factor (e_i) and the number of hours in a year (8760):

$$q_i = c_i * e_i * 8760$$

To calculate the subsidy equivalent, it was necessary to account for the proportion of electricity that was exported to the grid (x_i). The subsidy equivalent is then given by:

$$SE_i = \varphi_{i,x} * q_i * x_i$$

2 Implicit in this analysis is the assumption that in the absence of the FIT, households would be able to sell electricity into the grid and receive the wholesale price. This may not be a realistic assumption for all states. The net effect of this assumption would be to understate the subsidy equivalent to solar PV.

Variables are defined in table D.6, and estimated parameter values are reported in table D.7.

Table D.6 **Definitions**

Symbol	*Definition*	*Units*
$\varphi_{i,x}$	Production subsidy in jurisdiction *i* for electricity exported to the grid	A$/MWh
$\varphi_{i,d}$	Production subsidy in jurisdiction *i* for electricity used by the generator	A$/MWh
FIT_i	Feed-in tariff in jurisdiction *i*	A$/MWh
p_i	Average daytime wholesale electricity price	A$/MWh
q_i	Eligible electricity generation	MWh
c_i	Eligible generation capacity in jurisdiction *i* at the end of 2010	MW
e_i	Capacity factor (average annual generation per MW of capacity)	%
SE_i	Subsidy equivalent in jurisdiction *i*	A$
x_i	Export factor (proportion of electricity exported to the grid)	%
h_i	Number of hours the program was running in jurisdiction *i*	hours

Estimating 2010 solar electricity generation in Western Australia

The Western Australian FITs only commenced in August 2010. Hence, a different approach was needed to estimate the relevant generation in that state. In this case, estimated generation is given by:

$$q_i = (c_i * e_i * h_i) / 2$$

Estimating subsidy equivalents for gross FITs

Where gross FITs are paid, the subsidy equivalent consists of two elements: the subsidy for electricity exported to the grid, and the subsidy for electricity consumed by the generator. For the electricity that was exported to the grid, the subsidy equivalent was estimated in the same way as for net FITs. For the electricity that was consumed by the generator, the production subsidy equivalent is given by:

$$\varphi_{i,d} = FIT_i$$

Hence, the subsidy equivalent for states with a gross FIT is given by:

$$SE_i = [\varphi_{i,x} * q_i * x_i] + [\varphi_{i,d} * q_i * (1 - x_i)]$$

For the ACT, the quantity of electricity eligible for FITs was estimated in the same way as for Victoria, Queensland and South Australia. Because the FIT rates in New South Wales changed in October, a different approach was necessary.

Estimating 2010 solar electricity generation in New South Wales

The New South Wales gross FIT was 60 cents/kWh for systems installed before 27 October 2010 (FIT_1) and 20 cents/kWh for systems installed after (FIT_2). This implies that there were effectively four production subsidy equivalent rates during 2010:

$\varphi_{1,x} = FIT_1 - p_i$ production subsidy for electricity exported under FIT_1

$\varphi_{1,d} = FIT_1$ production subsidy for user-consumed power under FIT_1

$\varphi_{2,x} = FIT_2 - p_i$ production subsidy for electricity exported under FIT_2

$\varphi_{2,d} = FIT_2$ production subsidy for user-consumed power under FIT_2

In order to estimate the subsidy equivalent, the Commission has estimated how much generation was eligible for each FIT: q_1 is the amount of electricity eligible for FIT_1, and q_2 the amount of electricity eligible for FIT_2. The Commission has assumed that solar PV systems were installed at an even rate throughout the year. This implies that q_1 and q_2 are equal to the darker and lighter shaded areas in figure D.2 respectively. Formally, q_1 and q_2 are given by the following formulae:

$$q_1 = c_i * e_i * (h_1/8760) * (h_1/2 + h_2)$$

$$q_2 = c_i * e_i * (h_2/8760) * (h_2/2)$$

The subsidy equivalent is the sum of both components, exported and within household, for both tariffs.

$$SE = \{ [\varphi_{1,x} * q_1 * x] + [\varphi_{1,d} * q_1 * (1-x)]\} + \{[\varphi_{2,x} * q_2 * x] + [\varphi_{2,d} * q_2 * (1-x)]\}$$

Results

The estimated subsidy equivalents for 2010 range from A$2.2 million in Western Australia and the ACT to A$42.6 million in New South Wales (table D.8). The combined subsidy equivalent for all jurisdictions was around A$96 million.

It should be noted that on 13 May 2011 the New South Wales Government announced its intention to reduce the feed-in tariff rate for all solar receiving the New South Wales FITs to A$40/MWh. This would reduce the subsidy equivalent estimate. However, as of the time of writing, the details of this policy were unclear.

Figure D.2 **Stylised representation of electricity generation under the FIT in New South Wales**

Australia, 2010

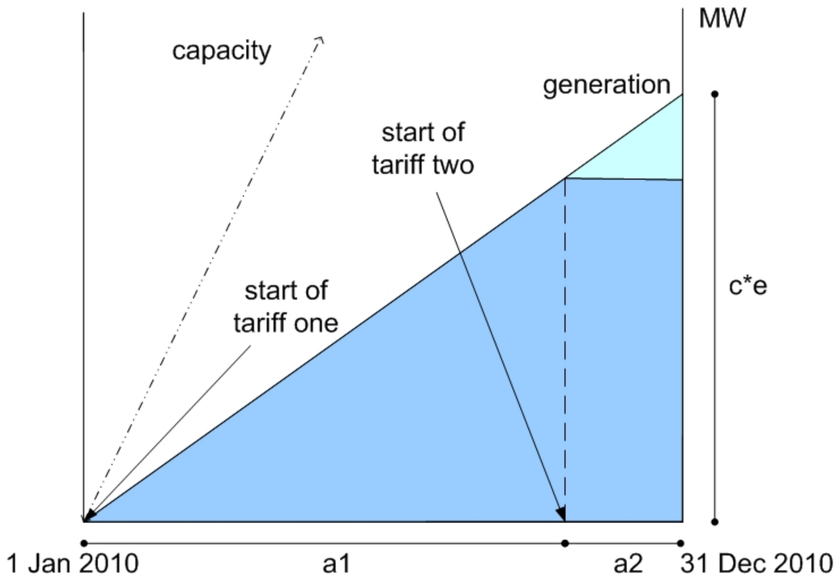


Table D.7 **Parameter values, feed-in tariffs**

Australia, 2010

Jurisdiction	*FIT*	*p*	*c*	*e*	*x*	*h*
	A$/MWh	A$/MWh	MW			hours
QLD	440	51.4	81.5	0.15	0.5	
NSW	FIT_1 = 600 FIT_2 = 200	73.1	117.6	0.15	0.5	h_1 = 7 200 h_2 = 1 560
ACT	457[a]	73.1	4.0	0.15	0.5	
VIC	600	45.2	61.6	0.15	0.5	
SA	440	100.9	27.5	0.15	0.5	
WA	400	35.3	44.2	0.15	0.5	3 672

Source: Frontier Economics (unpublished data); Productivity Commission estimates.

[a] Note that the rates in the ACT were A$501/MWh (for systems up to 10 kW) and A$400/MWh (for systems between 10–30 kW) for the first half of 2010. The Commission was unable to locate data on the generation receiving the different FIT rates, and therefore has assumed that the rate was equal to the FIT rate operating for all systems from 1 July 2010 — A$457/MWh.

Table D.8 **Subsidy equivalents, state feed-in tariffs**
Australia, 2010

Jurisdiction	φ_x	φ_d	*q*	*SE*
	A$/MWh	A$/MWh	GWh	A$m (2010)
Net FITs				
Victoria	555	..	81	22.5
Queensland	389	..	107	20.8
Western Australia	365	..	12	2.2
South Australia	339	..	36	6.1
Gross FITs				
New South Wales	$\varphi_{1,x} = 527$ $\varphi_{2,x} = 127$	$\varphi_{1,d} = 600$ $\varphi_{2,d} = 200$	$q_1 = 75$ $q_2 = 2$	42.6
ACT	384	457	5	2.2
Total			318	96

.. not applicable

Source: Productivity Commission estimates.

Abatement

As stated in section D.3, the state FITs overlap completely with the federal RET scheme. Each MWh of electricity subsidised through state FITs in 2010 led to the creation of RECs that could be used to meet the RET. As such, each MWh of solar electricity simply offsets abatement from other renewable sources. Given that the RET sets a binding target for the use of renewables, the state FITs do not lead to any additional abatement. With the changes to the RET in 2011, this may no longer be the case.

In fact, the nature of the RET in 2010 meant that if the state FITs did induce any additional supply of electricity from solar PV, this would have resulted in a net *increase* in emissions. The reason is that for each MWh of electricity generated through solar PV, owners of systems were granted 5 RECs, so each 'solar-generated REC' was equivalent to only 0.2 MWh of renewable electricity. In general, other renewable generators received only one REC per MWh. Hence, each 'solar-generated REC' that was surrendered in 2010 would have reduced the net generation from renewables by 0.8 MWh, leading to higher aggregate greenhouse gas emissions than if the solar system had not been installed.

Implicit abatement subsidy for solar

As noted, the fact that generation eligible for state FITs in 2010 was also eligible for the RET means that the state FITs did not induce any additional abatement in 2010. However, the FITs did increase the costs to the community of using solar power (because high-cost solar PV displaced lower-cost renewables in the RET target). Therefore, the subsidy equivalent for the FITs (A$96 million) can be added to the estimated subsidy equivalent for the small-scale component of the RET (A$52 million–A$98 million) to estimate the subsidy equivalent to solar PV in 2010. This figure can then be divided by the abatement credited to the small-scale component of the REC (0.2–0.3 Mt CO_2) to estimate the implicit abatement subsidy for abatement through solar PV in 2010. This figure comes in at A$432–A$1043/t CO_2, making the combined effects of the state FITs and small-scale component of the RET one of the highest-cost abatement options identified in this study.

D.6 NSW and ACT Greenhouse Gas Reduction Scheme

GGAS was introduced in NSW in 2003 and the ACT in 2005. GGAS is currently administered by the Independent Pricing and Regulatory Tribunal (IPART) (in the ACT the compliance regulator function for GGAS is performed by the Independent Competition and Regulatory Commission (ICRC)). The ACT GGAS mirrors NSW GGAS. Participants in both schemes are able to surrender certificates created under either the NSW or ACT GGAS. Therefore, the Commission has estimated the subsidy equivalent, abatement and implicit abatement subsidy of the NSW and ACT GGAS as one scheme.

The GGAS scheme was intended to reduce the annual carbon dioxide emissions of the electricity sector in NSW to a benchmark of 7.27 t CO_2 per person in 2009. This is implemented through a 'baseline and credit' system, whereby electricity retailers and some other organisations are legally required to surrender offset certificates if the CO_2 emissions associated with the electricity they supply exceed their benchmark. The firm-level emissions benchmark is determined by market share. Around 23 million certificates were surrendered in 2009. In addition, a relatively small number of certificates were voluntarily surrendered by around 115 organisations and individuals.

Electricity retailers are able to surrender either RECs or NGACs to meet their benchmark. In 2009, around 2.5 million RECs were accepted under GGAS — compared to 23 million NGACs. RECs surrendered under GGAS are also counted under the RET scheme. To avoid double counting of abatement from these

RECs, the Commission has only considered RECs in the analysis of the RET scheme (section D.4). The ability to surrender RECs under GGAS was not expected to have influenced REC prices in 2010. This is because the REC price reflects the additional cost of the marginal renewable electricity generator required to meet the renewable energy target under the RET. Because the GGAS does not induce any additional renewables, it should have no effect on the price of RECs. For this reason, the Commission has not considered the interaction between the GGAS and RET schemes in the estimates of the subsidy equivalent.

NGACs are intended to represent a one tonne reduction in CO_2 emissions and can be established based on the following rules:

- the generation rule
- the demand-side abatement rule
- the carbon sequestration rule
- the large user abatement rule (which allows large electricity customers to claim certificates for reducing on-site emissions from non electricity-related industrial processes at sites they own and control).

As the Commission's analysis focuses on generation of electricity, only NGACs created under the generation rule have been examined. Under the generation rule, generators receive NGACs for either producing electricity that has lower emissions intensity than the NSW average, or reducing the emissions associated with generation that has higher emissions intensity than the NSW average. Credit is given for improvements in 'current greenhouse performance' relative to the baseline, which is defined in terms of prior practice, business as usual, or current industry practice.

Around 15.5 million NGACs were attributed to generators in 2009. This corresponds to around 84 per cent of all NGACs created in 2009. Of generation related NGACs, natural gas and waste coal mine gas projects accounted for around 4 million each, and landfill gas and coal projects accounted for around 3 million each.

The Commission was not able to obtain data on the number of NGACs created in 2010 and has instead used data for 2009. All relevant estimates are reported in 2010 dollars. There have been a number of changes to GGAS since 2009 that may affect the Commission's estimates. These changes were implemented in preparation for the introduction of the proposed Carbon Pollution Reduction Scheme at the time. Relevant changes include:

- new applications for GGAS accreditation were closed on 31 December 2009

- the creation of certificates from some types of generation projects was stopped on 30 June 2010
- the eligibility of energy efficiency demand-side abatement projects was removed on 30 June 2009 (IPART 2011b).

The changes all have the effect of reducing the supply of NGACs in 2009 and 2010, resulting in higher NGAC prices than would otherwise have been the case.

Estimating the subsidy equivalent

The subsidy equivalent for GGAS was estimated by multiplying the number of NGACs issued in 2009 by the average spot market price of NGACs in 2009, expressed in 2010 dollars.

In 2009, the spot market price of NGACs was A$4.34 (A$4.57 in 2010 dollars) (IPART 2011b). The Commission has used the spot market price rather than some composite that takes into account the prices associated with long-term NGAC contracts, because the spot market price better reflects the economic value of the NGACs in 2009 and the financial incentives to participants to create NGACs.

15.5 million NGACs were created in 2009. However, this number included some abatement that is not additional to that which would have occurred in the absence of GGAS. According to the Department of Climate Change:

> GGAS includes non-additional abatement because it applies simple rules (baselines) to assess abatement, and imposes no additional test to discern whether that abatement would have occurred in any event. Examples of the sorts of non-additional activity that could be rewarded under GGAS include:
>
> - output from new gas-fired generators in the National Electricity Market, regardless of whether that new gas-fired generator would have been built and operated even without the support of GGAS; and
> - improvements in efficiency of coal-fired generators, even if those efficiency improvements are economic in their own right. (DCC 2010, pp. 1–2)

Estimates reported in DCCEE (2011c) imply GGAS is leading to 0.7 Mt of additional abatement annually. The Commission has not independently verified this estimate and hence cannot vouch for its accuracy. As 84 per cent of NGACs in 2009 were created by generators, this implies that 0.6 million of the NGACs created by generators in 2009 were for actions that would not have taken place without the scheme. As these NGACs were largely created for non-renewable electricity sector reductions they are not expected to overlap with the other measures analysed for Australia.

Using this estimate of the number of additional NGACs in 2009, multiplied by the 2009 spot price (A$4.57 in 2010 values), the subsidy equivalent of GGAS was estimated to be A$2.7 million. Note that this excludes the value of NGACs attributable to 'non-additional' abatement. This is appropriate because this portion is simply a transfer, and in estimating the subsidy equivalent the Commission is attempting to measure the resource costs associated with actual abatement.

Estimating abatement

Each NGAC is intended to represent a reduction in emissions of one tonne of CO_2. Therefore, abatement was simply equal to the number of additional NGACs, 0.6 million (0.6 Mt CO_2).

Implicit abatement subsidy

The implicit abatement subsidy for GGAS in 2009 was estimated by dividing the subsidy equivalent by abatement. Based on the above estimates, the implicit abatement subsidy was estimated to be A$4.57/t CO_2 — the NGAC spot price in 2009 (converted to 2010 values).

D.7 Queensland Gas Scheme

The Queensland Gas Scheme commenced in 2005, with a requirement on electricity retailers to surrender Gas Electricity Certificates (GECs) in proportion to the amount of electricity they sell. This is intended to ensure that a minimum percentage of Queensland's electricity is sourced from eligible gas generation, including natural gas, coal seam gas, liquefied petroleum gas and some waste gases (DME 2011). Generators that produce eligible gas electricity can apply to become accredited under the scheme, after which time, each MWh of electricity sent out above 2000 levels is eligible for one GEC. A GEC cannot be created from electricity that has been used to create a certificate under another state or Commonwealth greenhouse gas abatement scheme. The mandatory target was 13 per cent in 2009 and 15 per cent in 2010.

The Commission was unable to access Queensland Gas Scheme data for 2010. As a result, the analysis was undertaken for 2009 with values converted to 2010 values using GDP deflators for Australia. There were some differences between 2009 and 2010 that may affect the Commission's estimates for 2009. As discussed above, the mandatory target was increased to 15 per cent in 2010. Despite the increase in the mandatory target, the price of GECs was approximately A$4 lower in 2010. As a result, using 2009 data as a proxy for 2010 may result in an underestimation of the subsidy equivalent and abatement from the scheme in 2010 — as the target was lower in 2009. However, as the GEC price was lower in 2010, it may also represent an overestimate.

Estimating the subsidy equivalent

The Queensland Gas Scheme is conceptually similar to a renewable energy target, in that a minimum quota is established for a particular type of electricity — in this case, gas. The subsidy equivalent for the Queensland Gas Scheme in 2009 was given by the number of GECs created multiplied by the price of GECs.

In 2009, 5.6 million GECs were created (Queensland Government 2011) and the price of GECs was A$6.49 (DME 2010) (A$6.83 in 2010 values). Based on these figures, the subsidy equivalent was estimated to be A$38.3 million (in 2010 dollars).

Estimating abatement

Abatement from the Queensland Gas Scheme was estimated by multiplying the number of GECs (equivalent to 1 MWh of gas generation) created in 2009 by the difference in the emissions intensity of gas and the source of electricity that is assumed to be displaced by gas under the scheme.

In Queensland, each MWh of additional gas was assumed to displace 1 MWh of black coal. Based on table D.3, the average emissions intensity of gas was assumed to be 0.54 t CO_2/MWh and the average emissions intensity of black coal was assumed to be 0.92 t CO_2/MWh. Thus, each MWh of additional gas reduces emissions by 0.38 t CO_2. Multiplying this by the number of GECs created in 2009 provides an estimate of abatement of 2.1 Mt CO_2.

There are two reasons why this should be considered an upper-bound estimate of abatement from the Queensland Gas Scheme:

- First, the capacity of accredited power stations in Queensland increased from around 1500 MW in 2005 (the start of the scheme) to around 2700 MW in 2009 (DME 2010). It is likely that some of the rapid growth in gas generation was attributable to market factors and effects of public policy decisions that were unrelated to the Queensland Gas Scheme. This is supported by evidence from other NEM states, such as New South Wales and Victoria, which also experienced growth in gas-fired capacity over that period. In New South Wales, gas capacity increased by around 1100 MW, while in Victoria gas capacity increased by around 300 MW (ABARES 2011).

- Second, the discovery of substantial coal seam gas reserves in Queensland is likely to have contributed to growth in Queensland gas generation (even in the absence of the Queensland Gas Scheme). According to Daley and Edis (2011), there was a ten fold increase in the state's known coal seam gas reserves in the five years following the introduction of the scheme. It is not known to what extent these discoveries were motivated by the higher gas electricity prices resulting from the Queensland Gas Scheme.

Implicit abatement subsidy

The implicit abatement subsidy for the Queensland Gas Scheme in 2009 was estimated by dividing the subsidy equivalent by abatement. Based on the above estimates, the implicit abatement subsidy was estimated to be A$18/t CO_2.

D.8 Summary

This section summarises the above results and combines the estimates of subsidy equivalent and abatement for all the policies to generate estimates for the Australian electricity sector.

Total subsidy equivalent

The total subsidy equivalent is simply equal to the sum of the subsidy equivalents for each of the policies analysed (table D.9). In 2010, the total subsidy equivalent for Australia was estimated to be between A$473 million and A$694 million. This represented between 0.4 and 0.5 per cent of Australia's GDP.

Total abatement

As noted in section D.3, overlaps between policies have been accounted for in the estimates for individual policies. Thus the abatement estimates can be added together to provide an estimate of total abatement for Australia's electricity sector (no abatement has been attributed to the FITs because they overlap fully with the RET). In 2010, total abatement for the Australian electricity sector was estimated to be between 7–11 Mt CO_2 (table D.10).

In 2010, Australia's electricity sector emitted 196 Mt CO_2. Therefore, the abatement estimate represents between 3.6 per cent and 5.5 per cent of Australia's 2010 electricity sector emissions.

Table D.9 **Total subsidy equivalent**

Australia, 2010

	Total subsidy equivalent		
Policy	*'Central'*	*High*	*Low*
	A$m (2010)	A$m (2010)	A$m (2010)
Renewable Energy Target	356	556	335
Feed-in tariffs	96	96	96
Queensland Gas Scheme	38	38	38
Greenhouse Gas Reduction Scheme	3	3	3
Total	494	694	473

Source: Productivity Commission estimates.

Table D.10 **Total abatement**

Australia, 2010

Policy	*'Central'*	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
Renewable Energy Target	7	8	4
Greenhouse Gas Reduction Scheme	0.6	0.6	0.6
Queensland Gas Scheme	2[a]	2[a]	2[a]
Total	10	11	7

[a] The estimates of abatement under the Queensland Gas scheme should be interpreted as an upper bound.

Source: Productivity Commission estimates.

Average implicit abatement subsidy

Based on the estimates above, the average implicit abatement subsidy for the Australian electricity sector was estimated to be between A$44 and A$99/t CO_2 (table D.11).

Table D.11 **Average implicit abatement subsidy**
Australia, 2010

	Implicit abatement subsidy		
Total subsidy equivalent scenario	*High abatement*	*'Central' abatement*	*Low abatement*
	A$/t CO_2	A$/t CO_2	A$/t CO_2
High	65	69	99
'Central'	46	49	70
Low	44	47	67

Source: Productivity Commission estimates.

D.9 Other Australian electricity generation policies and programs

The Commission has only estimated the subsidy equivalent and abatement for a subset of emissions-reduction policies in Australia. In particular, this appendix has focused on policies that applied to the electricity generation sector in 2010, and were considered likely to be leading to material levels of abatement, or imposing material resource costs in that year.

The Commission did not analyse the effects of research and development or technology demonstration policies, because the link between current spending and abatement is tenuous. Nor were the effects of energy efficiency policies analysed in this appendix, because these policies relate to electricity consumption, rather than generation. These policies are analysed in greater depth in appendix C. Finally, the appendix does not address the effects of land use, planning or transport policies, although some of these policies could have a material effect on future emissions trends.

The Commission's analysis for the Australian electricity generation sector includes only those policies that passed a materiality threshold. While the four measures are only a fraction of those in place, they are considered to represent a large proportion of the total subsidy equivalent (and associated abatement) applicable in the electricity generation sector.

Excluded electricity generation policies

One policy — the Northern Territory Solar Cities program — was not included in the analysis due to data constraints. This program includes a feed-in tariff of 46 cents/kWh for small-scale solar PV supplying electricity to the

Northern Territory grid. However, as the abatement from feed-in tariffs overlaps with that of the RET, the Solar Cities program was assumed to have not contributed any additional abatement. Moreover, due to the small population of the Northern Territory, relative to other states and territories, the subsidy equivalent from this program was expected to be small. Therefore, it would probably not have a material effect on the Commission's estimates of the total subsidy equivalent.

The Commission identified a number of electricity sector measures that were not included in the analysis as they did not meet the Commission's materiality criteria for policy inclusion. These include:

- Queensland Renewable Energy Fund — A$50 million funding program to support the development and deployment of renewable electricity generation in Queensland
- Northern Territory 'Make the Switch' capital grants program — capital grants to tourism operators replacing fossil-fuel generators with renewable electricity
- Solar Schools programs (Commonwealth, South Australia and Western Australia Governments) — grants to eligible schools to install solar PV systems
- various other government grants for the development of renewable electricity. Examples include: the Commonwealth Government's A$1.5 billion Solar Flagship program (although this policy could have material effects in future years, in 2010 the effects were limited to the short listing of a number of solar PV projects, and the provision of funds to undertake feasibility studies); the Kogan Creek Solar Boost Project; the Victorian Large Scale Solar Project; and the Low Emissions Energy Development Fund.

The exclusion of these policies does not imply that they are not capable of reducing emissions. Rather, they were excluded because in 2010, the resource costs of the policies were probably small. In particular, each of these excluded policies relate to capital subsidies or grants. On an annualised basis, they probably did not provide a substantial subsidy equivalent relative to the other measures analysed in 2010.

A second consideration is that many of these policies subsidise renewables. While Australia has a binding RET, it was likely that these policies will not deliver additional abatement (because abatement through renewables was a function of the binding target).

Committed policies

The Commission did not identify any 'committed' policies, as defined in chapter 3, that are likely to have a material effect on future estimates of implicit abatement subsidies. However, the Australian Government has announced its intention to introduce an emissions trading scheme from 1 July 2012. The emissions trading scheme permit price is expected to be fixed for a period of three to five years before transitioning to a full emissions trading scheme. Such a policy could have a considerable effect on emissions and the subsidy to lower-emissions generation in Australia.